SOME FORAMINIFERA FROM THE AMPTHILL CLAY, UPPER JURASSIC, OF CAMBRIDGESHIRE

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ABSTRACT. Seventeen species of foraminifera are recorded from two samples of Ampthill Clay collected at Knapwell and Mepal, Cambridgeshire. One species is new. The foraminifera are compared with those of the sandy-calcareous facies of the Corallian Beds seen on the Dorset coast.

THE present paper is the first published work on the foraminifera of the Ampthill Clay, Oxfordian, Upper Jurassic, of England. It arises from a broader study of the Corallian foraminifera of southern England which was made for a Ph.D. thesis in the University of London.

Previous work on foraminifera from the Oxfordian rocks of England includes two useful papers by Barnard (1952, 1953) on the Upper Oxford Clay of Warboys, Huntingdonshire, and Redcliff Point, Dorset. Less valuable are the faunal lists published without illustration by Jones and Parker (1875), Whitaker (1886), and Crick (1887). The only other work is that by Sherborn (1888) on an adherent foraminifer from the Oxford Clay near Weymouth.

The material which forms the basis of the present paper was collected from the Ampthill Clay at the only two places where it could be found exposed at the surface, at Knapwell and at Mepal, both in Cambridgeshire. The exposure at Knapwell has been discussed by Hancock (1954) who recorded an ammonite fauna comprised of *Decipia lintonensis*, *D. decipiens*, and *Pseudarisphinctes spp.* He considered that the fauna represents a horizon above the Boxworth Rock and that it correlates with the upper part of the *Trigonia clavellata* beds of Dorset. The position of the Mepal exposure within the local Ampthill sequence is not known, but it is presumably equivalent to part of the Glos Oolite Series of Dorset. Details of the rock samples which were studied for their foraminifera are as follows:

(*a*) Knapwell Stream, Knapwell, Cambs. (Grid Ref. 52/331641). Dark-grey clay containing many selenite crystals. Fairly shelly. Stratigraphical thickness sampled: 24 inches.

(*b*) Toll Farm, Mepal, Cambs. (Grid Ref. 52/435813). Shelly dark grey clay. Stratigraphical thickness sampled: 8 inches.

Two hundred and twenty-three foraminifera were obtained from the Knapwell sample, and 307 from the Mepal sample. In addition to the foraminifera, both samples yielded ostracods abundantly, and the Mepal material included a number of crinoid ossicles, holothurian spicules, and a segment of the whorl of a small ammonite. In both samples there were many fragments of oyster and other lamellibranch shells.

Figured specimens of the foraminifera will be presented to the British Museum (Natural History).

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SYSTEMATIC DESCRIPTIONS

Family LITUOLIDAE

Genus CRIBROSTOMOIDES Cushman 1910

Cribrostomoides canui (Cushman)

Text-fig. 1 (1)

1929 *Haplophragmoides canui* Cushman, p. 133, pl. 4, figs. 1*a*, *b*.
1949 *Haplophragmoides canui* Cushman; Cushman and Glazevski, p. 4, pl. 1, fig. 3.
1959 *Ammobaculites laevigatus* Lozo; Lloyd, p. 313, pl. 54, fig. 14; text-fig. 4*a*.

Material. Three damaged specimens from Mepal.

Description. The test is planispiral, umbilicate, involute, tending to become evolute in the last half whorl. The thickness of the test is about half the greatest diameter, and the test wall is fairly smoothly constructed. There are nine or ten chambers in the final whorl. The aperture appears to be elliptical, centrally placed on the apertural face.

Dimensions. Greatest diameter of the specimens, 0·56, 0·57, and 0·74 mm.

Remarks. The Ampthill Clay specimens are rather larger than those described by Cushman (1929) from the Oxfordian of Calvados, Normandy, but there does not seem to be any essential difference between the two forms.

Genus AMMOBACULITES Cushman 1910

Ammobaculites agglutinans (d'Orbigny)

Text-fig. 1 (4)

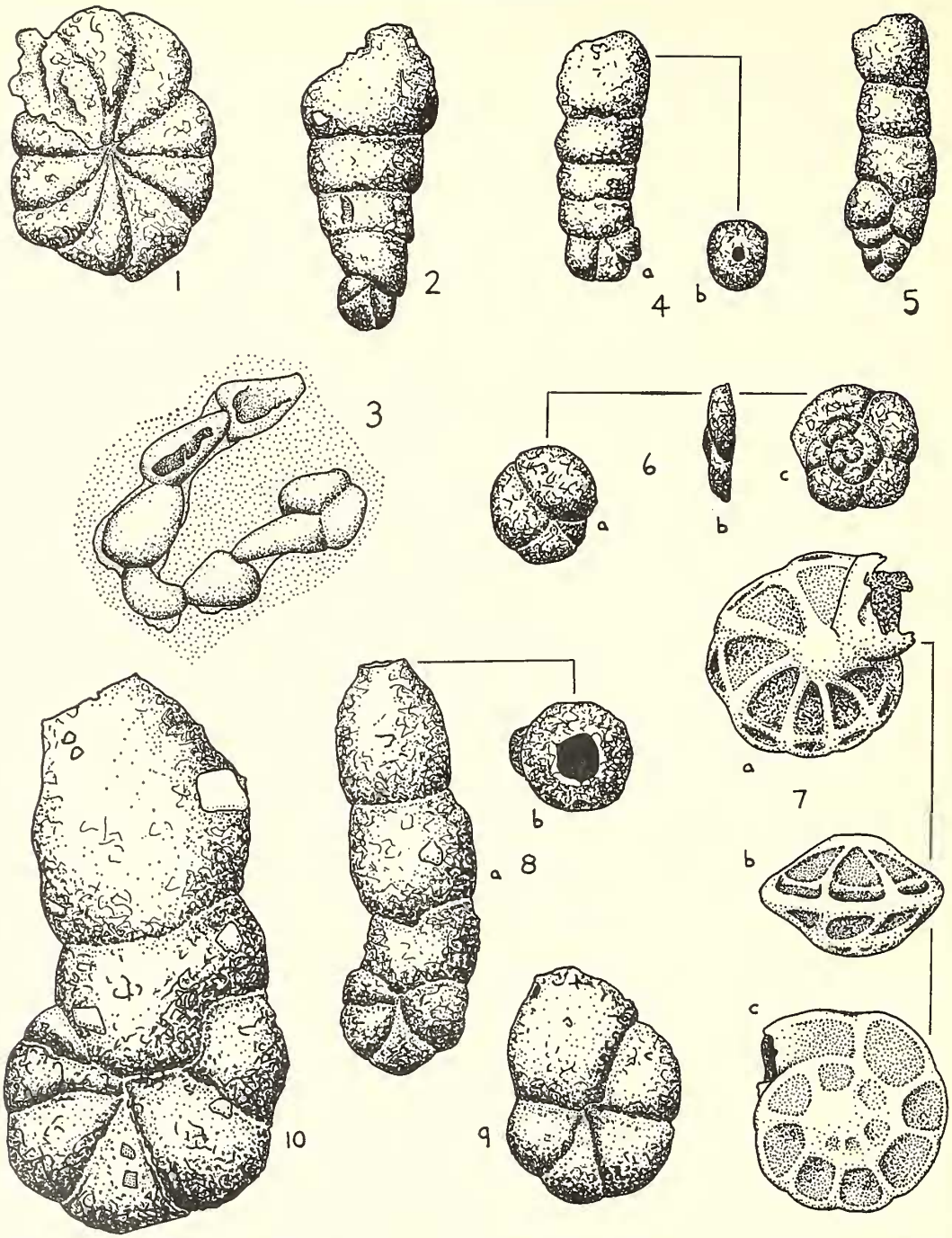
1846 *Spirolina agglutinans* d'Orbigny, p. 137, pl. 7, figs. 10–12.
1932 *Ammobaculites coprolithiformis* (Schwager); Paalzow, p. 94, pl. 4, fig. 19.
1937 *Ammobaculites agglutinans* (d'Orbigny); Bartenstein and Brand, p. 186, pl. 4, fig. 14; pl. 5, figs. 7, 8; pl. 6, figs. 40*a*, *b*; pl. 8, figs. 38*a*, *c*; pl. 10, figs. 45*a*, *b*; pl. 11A, figs. 19*a*, *b*; pl. 11B, figs. 28*a*, *b*; pl. 12A, fig. 22; pl. 13, fig. 23; pl. 14B, fig. 19.
1943 *Ammobaculites agglutinans* (d'Orbigny); Ströbel (pars), p. 14, pl. 12, fig. 22.
1959 *Ammobaculites agglutinans* (d'Orbigny); Lloyd, p. 309, pl. 54, figs. 9, 11 (? 10); text-figs. 4*b*, *d*, *e* (? *c*).

Material. Eleven specimens from Mepal.

Description. The test is slightly compressed and consists of a coil of three to five chambers followed by a rectilinear or curvilinear series of four or five chambers. The coil is usually about one-third of the size of the whole test, but it may be as much as half the test. It is angular in outline, sometimes umbilicate, and the chambers are often indistinct. The uncoiled part has depressed sutures, the chambers being irregular in form but commonly drum-shaped. The last formed chambers are often inflated. The wall of the test is roughly constructed of irregularly sized particles. The aperture is central, terminal, circular, with an internal lip of white calcite.

Dimensions. Length, 0·43–0·62 mm.

Remarks. The original description of this species was by d'Orbigny from the Tertiary of the Vienna Basin. In the Jurassic, forms which appear to be indistinguishable from the Tertiary species occur at least from the Bajocian to the Kimmeridgian.



TEXT-FIG. 1. (1) *Cribrostomoides canui* (Cushman). Mepal. ×60. (2) *Ammobaculites* cf. *reophaciformis* Cushman. Mepal. ×60. (3) *Bullopora rostrata* Quenstedt. Knapwell. ×60. (4)*a, b. Ammobaculites agglutinans* (d'Orbigny). Mepal. ×75. (5) *Bigenerina* cf. *nodosaria* d'Orbigny. Mepal. ×75. (6)*a–c. Trochammina squamata* Jones and Parker. Mepal. ×75. (7)*a–c. Voorthuysenia tenuicostata* (Bartenstein and Brand). Mepal. ×75. (8)*a, b. Ammobaculites coprolithiformis* (Schwager). Mepal. ×40. (9), (10) *Ammobaculites coprolithiformis* (Schwager). Knapwell. ×40.

Ammobaculites coprolithiformis (Schwager)

Text-fig. 1 (8), (9), (10)

1867 *Haplophragmium coprolithiforme* Schwager, p. 654, pl. 34, fig. 3.
1879 *Haplophragmium pictonicum* Berthelin, p. 26, pl. 1, figs. 1, 2.
1884 *Haplophragmium coprolithiforme* Schwager; Deecke, p. 20, pl. 1, fig. 5.
1885 *Haplophragmium coprolithiforme* Schwager; Haeusler, p. 13.
?1886 *Haplophragmium vetustum* Terquem and Berthelin; Deecke, p. 15, pl. 2, figs. 1–1*e*.
1886 *Haplophragmium coprolithiforme* Schwager; Deecke, p. 15, pl. 2, figs. 2–2*d*.
1890 *Haplophragmium coprolithiforme* Schwager; Haeusler, p. 33, pl. 4, figs. 7, 20.
1936 *Haplophragmium coprolithiforme* Schwager; Kuhn, p. 446, text-figs. 3, 4.
1939 *Ammobaculites subaequalis* Myatliuk, pp. 44, 70, pl. 2, figs. 19, 20.
1952 *Ammobaculites* cf. *coprolithiformis* (Schwager); Usbeck, p. 382, pl. 14, fig. 16.
1953 *Ammobaculites suprajurassicum* (Schwager); Barnard, p. 184, fig. A, 2*a*, *b*.
1954 *Ammobaculites coprolithiformis* (Schwager); Bielecka and Pozaryski, pp. 27, 161, pl. 3, figs. 6*a*, *b*.
1955 *Ammobaculites alaskensis* Tappan (pars), p. 43, pl. 12, figs. 1, 2, 4, 5, 9, 10.
1959 *Ammobaculites* cf. *coprolithiformis* (Schwager); Lloyd, p. 311, pl. 54, figs. 12*a*, *b*.
1959 *Ammobaculites subaequalis* Myatliuk; Lloyd, p. 311, pl. 54, figs. 16, 17.

Material. Sixty-seven specimens from Knapwell; 29 from Mepal.

Description. The test consists of a planispiral coil of two to six chambers, followed by an uncoiled series of up to six chambers. The coil makes up about one-third of the test and most commonly consists of three chambers. The uncoiled series usually begins with a drum-shaped chamber which partly embraces the coil, and this is followed by gently inflated chambers which increase irregularly in height. The uncoiled part is gently compressed and is straight, arcuate, or S-shaped. The sutures are distinct, depressed, radial on the coil, and approximately transverse on the uncoiled part. The end chamber is inflated, conical or pyriform. The wall of the test is roughly constructed, usually of quartz particles, and bound together by a white calcareous cement. The aperture is central, terminal, polygonal.

In early growth stages, the aperture resembles that of the adult in shape, but it is developed low on the apertural face in two- and three-chambered individuals. It usually becomes terminal when a fourth chamber is added.

Dimensions. Length, up to 2·13 mm.; usually between 0·8 and 1·5 mm.

Remarks. This species was first described by Schwager from the *sowerbyi* zone (Bajocian) of Württemberg. It has been recorded many times from the Oxfordian and seems to be at its greatest abundance at this level, although there are also records from the Lias of a large *Ammobaculites* which appears to belong to the same species.

Outside western and central Europe, this species has been found in the lower Volgian of the Saratov and Kuibyshev districts, U.S.S.R. (Myatliuk, 1937), the upper Oxfordian and lower Kimmeridgian of central Poland (Bielecka and Pozaryski, 1954), and the Lias and Upper Jurassic of northern Alaska (Tappan, 1955).

Specimens which have been referred to *A. coprolithiformis* (Schwager) by Colom (1952) from the Upper Cretaceous of Navarre and Soria, Spain, and by Cushman (1946) from the Upper Cretaceous of western Canada, south-eastern U.S.A., Trinidad, and Mexico, do not appear to belong to the same species.

Ammobaculites cf. *reophaciformis* Cushman

Text-fig. 1 (2)

cf. 1910 *Ammobaculites reophaciformis* Cushman, p. 440, text-figs. 12–14.

Material. One specimen from Mepal.

Description. The test consists of a small coil followed by four chambers which are arranged rectilinearly and which increase fairly rapidly in size. The coil is rounded, consisting of three chambers. The rectilinear part is slightly compressed and the chambers are drum-shaped except for the final chamber which is globular. The sutures on the rectilinear part are depressed weakly at first, more strongly later. The wall of the test is irregularly constructed of coarse, variably sized particles, and has a calcareous cement. The aperture is not preserved on the only specimen available.

Dimensions. Length of the specimen, 0·83 mm.

Remarks. This form is similar to *Ammobaculites reophaciformis* which was described by Cushman from present-day seas off the Philippine Islands, but the Ampthill Clay specimen is smaller, and the sutures are more constricted. A new species should perhaps be erected for the Jurassic form when additional material becomes available. The present author has found three other specimens of this form in the upper part of the Corallian Beds of the Dorset coast, but these were not well preserved.

Family TEXTULARIIDAE

Genus BIGENERINA d'Orbigny 1826

Bigenerina cf. *nodosaria* d'Orbigny

Text-fig. 1 (5)

cf. 1826 *Bigenerina* (*Bigenerine*) *nodosaria* d'Orbigny, p. 261, pl. 11, figs. 9–12.
1890 *Bigenerina nodosaria* d'Orbigny; Haeusler, p. 73, pl. 12, figs. 1–4.

Material. Four specimens from Mepal.

Description. The test consists of six or seven biserial chambers, followed by three to five chambers arranged uniserially. The early sutures are indistinct and the test wall is roughly constructed of irregularly sized particles. The aperture is not preserved on any specimen.

Dimensions. Lengths of the specimens, 0·47, 0·49, 0·52, and 0·53 mm.

Remarks. The Ampthill Clay specimens, which are not well preserved, appear to be morphologically indistinguishable from the type of the species from the Recent, Adriatic Sea.

Family OPHTHALMIDIIDAE

Genus BULLOPORA Quenstedt 1856

Bullopora globulata Barnard

cf. 1858 *Bullopora sp.* Quenstedt, p. 554, pl. 72, fig. 35.
1950*a* *Bullopora globulata* Barnard, p. 378, fig. 1*e*.

Material. One specimen from Knapwell.

Dimensions. Width of the only chamber outside the initial coil, 0·13 mm.

Remarks. A single specimen, adhering to a fragment of oyster shell, is referred to this species. Apart from its smaller size, this specimen seems to be indistinguishable from the type which was described by Barnard from the Lower Lias of Dorset. Similar specimens occur in the Corallian rocks of Dorset, and these are likewise slightly smaller than the type specimen.

Bullopora rostrata Quenstedt

Text-fig. 1 (3)

1858 *Bullopora rostrata* Quenstedt, p. 580, pl. 73, fig. 28.
1935 *Bullopora rostrata* Quenstedt; Macfadyen, p. 18, pl. 1, figs. 23, 24.
1941 *Bullopora rostrata* Quenstedt; Macfadyen, p. 25, pl. 1, figs. 13–17.
1952 *Bullopora rostrata* Quenstedt; Barnard, p. 348, fig. B, 8.
1953 *Bullopora rostrata* Quenstedt; Barnard, p. 192.

Material. Five specimens from Knapwell.

Description. The adherent, imperforate, white, opaque test consists of up to twelve chambers. It starts with a loose coil of three hemi-ellipsoidal chambers and this is followed by a meandrine series of chambers which are hemi-ellipsoidal or irregular in shape at first, but which soon become elongate and bulbous or club-shaped. After the initial part there is no increase in the size of the chambers. The aperture is terminal, simple, semicircular. All the specimens were attached to lamellibranch shell fragments.

Dimensions. Greatest width of the chambers, 0·09–0·15 mm.

Remarks. Bullopora rostrata was described by Quenstedt from the Oxfordian (*Impressa* Beds) of Reichenbach, Saxony, and Macfadyen (1941) has given a long synonymy for this species. Unfortunately, there seems to be some confusion in the literature between a perforate and an imperforate speeies of adherent foraminifer which are broadly isomorphous in gross morphology, and it is not felt to be advisable to attempt a lengthy synonymy at this time. Forms which appear to be similar to the Ampthill Clay material are reported widely in Europe from the Lower Lias to the Oxfordian, but the only non-European record appears to be that of Macfadyen (1935) from probable Argovian, British Somaliland. Some of the Lias specimens differ slightly from the Ampthill form in having more slender chambers.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones 1859

Trochammina squamata Jones and Parker

Text-fig. 1 (6)

1860*a* *Trochammina squamata* Jones and Parker, p. 304.
1890 *Trochammina squamata* Jones and Parker; Haeusler, p. 65, pl. 10, figs. 27–29, 40.
1937 *Trochammina squamata* Jones and Parker; Bartenstein and Brand, p. 190, pl. 6, fig. 41; pl. 11B, fig. 29; pl. 15C, figs. 22*a*, *b*.
1959 *Trochammina squamata* Jones and Parker; Lloyd, p. 316, pl. 54, fig. 29; text-fig. 5*a*.

Material. Three specimens from Mepal.

Dimensions. Greatest diameter of the tests, 0·28, 0·29, 0·31 mm.

Remarks. There is nothing to add to previous descriptions. The Upper Jurassic forms which have been ascribed to this species are indistinguishable from the original material which was described by Jones and Parker from the Recent, off the island of Crete.

Family LAGENIDAE
Genus LENTICULINA Lamarck 1804

Forms which here are placed in the genus *Lenticulina* would be called *Cristellaria* by some authors, but Glaessner (1945) considers that *Cristellaria* Lamarck 1816 is probably invalid. He states that it is probably a synonym of one or more of the many names given by Montfort in 1808. Most of these in turn are probably synonyms of *Lenticulina*. Cushman (1950) states that 'in many species it is very difficult to separate *Robulus* from *Lenticulina* and it may be best as a practical matter to drop *Robulus* and use *Lenticulina* for both'. *Cristellaria* Lamarck 1816 is regarded by him as a synonym of *Robulus* Montfort 1808.

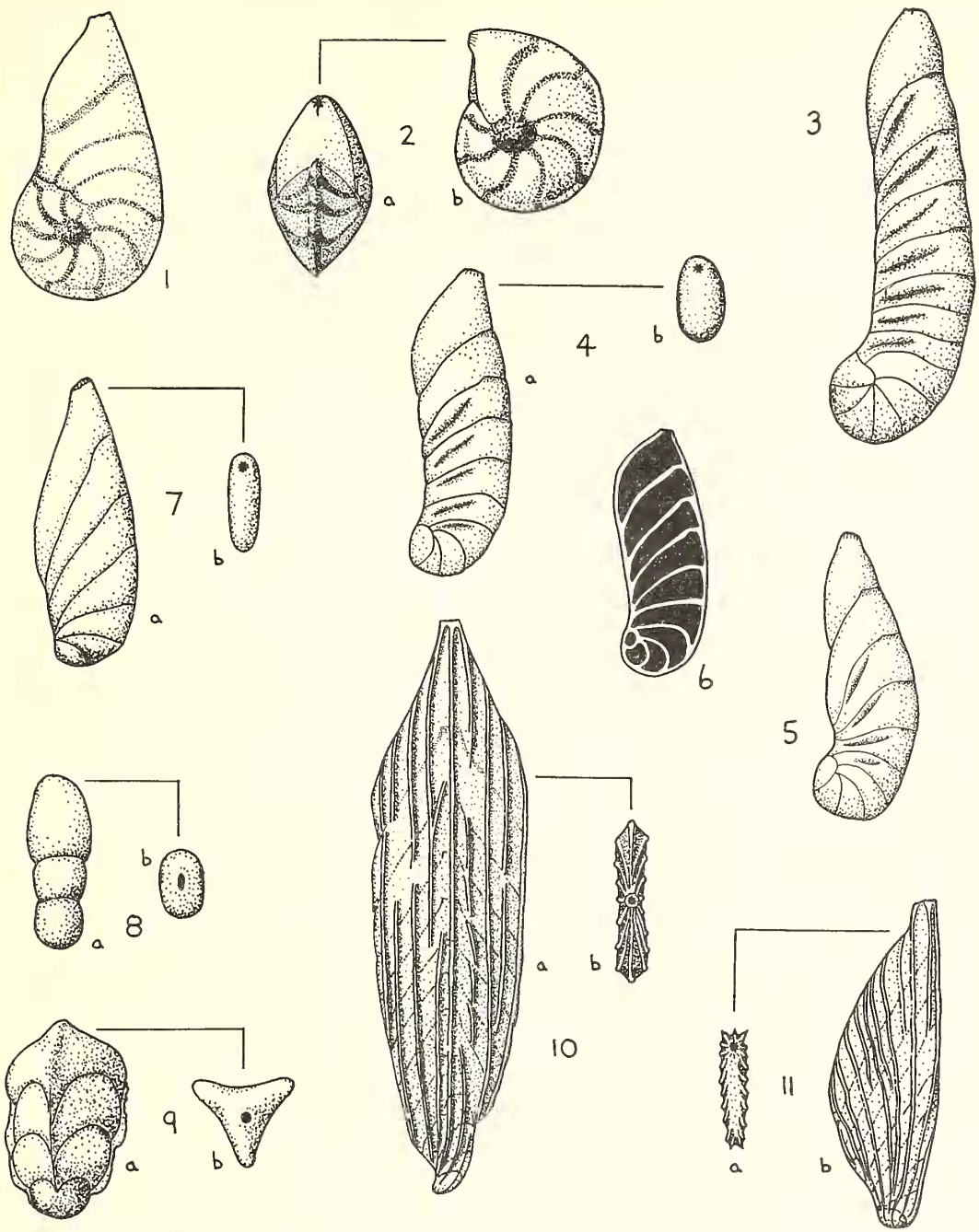
Lenticulina münsteri (Roemer)

Text-fig. 2 (1), (2)

1839 *Robulina münsteri* Roemer, p. 48, pl. 20, figs. 29*a*, *b*.
?1839 *Robulina gibba* Roemer, p. 47, pl. 20, figs. 30*a*, *b*.
?1865 *Cristellaria semiexpleta* Schwager, p. 134, pl. 7, figs. 1*a*, *b*.
1867 *Cristellaria sowerbyi* Schwager, p. 660, pl. 34, fig. 18.
1867 *Cristellaria vulgaris* Schwager, p. 661, pl. 34, fig. 19.
1884 *Cristellaria sowerbyi* Schwager; Deecke, p. 50, pl. 2, fig. 18.
1884 *Cristellaria rotulata* (Lamarck); Jones, pp. 765, 767, 770, pl. 34, fig. 9.
?1886 *Cristellaria sowerbyi* Schwager; Deecke, p. 34, pl. 2, figs. 34, 34*a*.
1892 *Cristellaria cultrata* (Montfort); Crick and Sherborn, p. 70, pl., figs. 13*a*, *b*.
?1904 *Cristellaria rotulata* (Lamarck); Chapman, p. 192, pl. 22, fig. 9.
1932 *Lenticulina münsteri* (Roemer); Paalzow, p. 101, pl. 5, figs. 23, 24; pl. 6, figs. 1, 2.
1935 *Cristellaria münsteri* (Roemer); Macfadyen, p. 13, pl. 1, figs. 10*a*, *b*.
1937 *Cristellaria* (*Lenticulina*) *münsteri* (Roemer); Bartenstein and Brand, p. 174, pl. 3, figs. 30*a*, *b*; pl. 4, figs. 69*a–c*; pl. 6, figs. 34*a–d*; pl. 9, figs. 49*a–e*; pl. 10, figs. 38*a*, *b*; pl. 11A, figs. 13*a–d*; pl. 11B, figs. 19*a–d*; pl. 12A, figs. 16*a*, *b*; pl. 12B, figs. 15*a–e*; pl. 13, fig. 36; pl. 14B, figs. 14*a–c*; pl. 14C, figs. 13*a*, *b*; pl. 15A, figs. 34*a–c*; pl. 15C, figs. 19*a–c*.
1938 *Cristellaria* (*Lenticulina*) *variata* Bornemann; Wicher, pl. 20, fig. 5.
1941 *Cristellaria münsteri* (Roemer); Macfadyen, p. 31, pl. 2, figs. 23*a*, *b*.
1950*b* *Lenticulina münsteri* (Roemer); Barnard, p. 7, pl. 2, fig. 1.
1952 *Lenticulina münsteri* (Roemer); Barnard, p. 339, fig. B, 5.
1953 *Lenticulina münsteri* (Roemer); Barnard, p. 185, fig. A, 10.
1954 *Lenticulina münsteri* (Roemer); Bielecka and Pozaryski, pp. 33, 165, pl. 4, figs. 12*a*, *b*.

Material. Thirty-eight specimens from Knapwell; 55 from Mepal.

Description. The test is composed of one and a half whorls which are at first involute, but which may become evolute. In some individuals there are about ten chambers in the last whorl, and the thickness of the test is one-third to almost one-half of the greatest diameter of the test. The periphery is subangular to carinate, smoothly curving or polygonal. Sometimes the thickness of the test wall at the periphery gives the appearance of a keel in side view when the test is in fact not carinate. The umbilicus usually has an infilling of clear calcite which is flush with the surface of the test, but some-



TEXT-FIG. 2. (1) *Lenticulina münsteri* (Roemer). Mepal. ×40. (2)*a, b. Lenticulina münsteri* (Roemer). Knapwell. ×40. (3) *Lenticulina suprajurassica* sp. nov. Holotype. Mepal. ×40. (4)*a, b,* (5) *Lenticulina suprajurassica* sp. nov. Paratypes. Mepal. ×40. (6) *Lenticulina suprajurassica* sp. nov. Longitudinal section. Mepal. ×40. (7)*a, b. Planularia fraasi* (Schwager). Knapwell. ×75. (8)*a, b. Lingulina nodosaria* Reuss. Knapwell. ×75. (9)*a, b. Tristix oolithica* (Terquem). Knapwell. ×75. (10)*a, b. Falsopalmula anceps* (Terquem). Knapwell. ×40. (11)*a, b. Citharina serratocostata* (Gümbel). Mepal. ×40.

times there are raised umbilical bosses which give the test a globose appearance. The sutures are limbate, flush, or raised into low ribs, and they curve with the convex side towards the aperture, but with a sharp recurvature at the periphery. The proloculum is spherical.

Individuals which uncoil have up to five chambers arranged in a straight or curving terminal series, and the later ones of these may be inflated. In this portion the sutures slope back strongly or weakly towards the proloculum at the non-apertural margin. They become less limbate, ribs which may be present earlier in the test now disappear, and finally the sutures become depressed.

The aperture is marginal, terminal, radiate, sometimes on a small extension of the final chamber.

Dimensions. Length of the largest uncoiling specimen, 1·3 mm. In completely coiled individuals, the greatest diameter of the test is usually about 0·7 mm.

Remarks. Lenticulina münsteri was originally described from the Lower Cretaceous (Hils) of Schöppenstedt, north Germany, but it has subsequently been recorded throughout the Jurassic of Europe. Outside Europe, Chapman (1904) illustrates a form which is possibly the same species from the Jurassic of Western Australia, and Macfadyen (1935) has recorded it from probable Argovian, British Somaliland. The characteristics of the form which most authors refer to Roemer's '*Robulina münsteri*' are clear, but the type reference of the species is far from satisfactory.

Lenticulina suprajurassica sp. nov.

Text-fig. 2 (3), (4), (5), (6)

?1870*a* *Cristellaria hybrida* Terquem (pars), p. 441, pl. 14, figs. 14*a*, *b*, 17, 19.
?1954 *Lenticulina prima* (d'Orbigny); Bielecka and Pozaryski, pp. 38, 170, pl. 5, figs. 19*a*, *b*.
1955 *Lenticulina* (*Astacolus*) *prima frauconica* (Gümbel); Seibold and Seibold, p. 109, text-figs. 3*k*, *l*, pl. 13, fig. 6.

Material. Seven specimens from Knapwell; 58 from Mepal.

Description. The test has an initial coil of four to six chambers, followed by a curving series of up to eight chambers. It is compressed, the thickness of the test being about half the width. The initial coil is globose, evolute, with a subangular periphery which becomes rounded later. The first two or three sutures are flush, curving, but subsequent sutures are depressed at the non-apertural margin and flush or raised into low ribs at the sides and apertural margin. In the uncoiled part of the test, the sutures are at first transverse, but rapidly become oblique, sloping towards the initial end at the non-apertural margin. The uncoiled chambers are characteristically more than twice as broad as they are high, and in many specimens they are ornamented by a broad groove on each side of the test. This ornament does not appear to be a secondary effect caused by crushing. The end chamber is usually inflated, but is little differentiated from the preceding chambers. The aperture is terminal, marginal, radiate, and is sometimes on a small projection of the final chamber.

Dimensions. Length, up to 1·66 mm.; usually about 0·8–1·1 mm.

Remarks. This species is distinguished from most other uncoiling *Lenticulinae* in the

Jurassic by its brief evolute coil, the lowness of the chambers in the uncoiled part, and the typically curvilinear rather than rectilinear form of the uncoiled part.

Some of the many forms from the Bajocian of eastern France which Terquem has grouped together as *Cristellaria hybrida* may belong here. Other similar forms have been recorded from the Kimmeridgian and Portlandian of Poland (Bielecka and Pozaryski 1954), but they have a coil of about ten chambers, and the curvilinear chambers are not so low as those of the Ampthill Clay forms. The Seibolds' form from the Oxfordian of south Germany appears to be very close to the Ampthill Clay specimens. The Brady collection of foraminifera at the British Museum (Natural History) includes specimens from the Kimmeridge Clay which are identical with the Ampthill material.

Genus PLANULARIA Defrance 1824

Planularia fraasi (Schwager)

Text-fig. 2 (7)

non 1854 *Cristellaria protracta* Bornemann, p. 39, pl. 4, figs. 27*a*, *b*.
1865 *Cristellaria fraasi* Schwager (non Gümbel, 1871), p. 123, pl. 5, fig. 10.
1865 *Cristellaria lanceolata* Schwager, p. 130, pl. 6, fig. 13.
1952 *Planularia protracta* (Bornemann); Barnard, p. 343, figs. C, *a–d*.
1953 *Planularia protracta* (Bornemann); Barnard, p. 186, fig. A, 4.
1956 *Lenticulina* (*Planularia*) *lanceolata* (Schwager); Seibold and Seibold, p. 113, text-figs. 6*p*, *q*; pl. 7, fig. 6.

Material. Five specimens from Knapwell.

Description. The compressed, lanceolate test lacks ornament and is composed of about eight chambers. The length of the test is two to three times its greatest width, and the thickness is about one-third of the width. The initial coil is variable and irregular in form and has been discussed by Barnard (1952). The aperture is radiate.

Dimensions. Length, 0·41–0·57 mm.

Remarks. The stylized illustrations and generalized descriptions given by many of the older authors make difficult the construction of an adequate synonymy for these forms. Many of the smooth Upper Jurassic *Planulariae* have been referred to *Planularia protracta*, described by Bornemann from the Lower Lias of Göttingen, but the Upper Jurassic forms appear to differ from this in several ways. They are not so elongate, the initial coil is better developed and is more irregular in form, and the later chambers extend more strongly back towards the proloculum at the non-apertural margin. Schwager's original description of *Planularia fraasi* was from the Oxfordian of Franconia.

Genus NODOSARIA Lamarck 1812

Nodosaria sowerbyi Schwager

1867 *Nodosaria sowerbyi* Schwager, p. 656, pl. 34, fig. 8.

Material. One specimen from Knapwell.

Dimensions. Length, 0·63 mm.

Remarks. A single specimen composed of six chambers is referred to this species which

Schwager described from the *sowerbyi* Zone (Bajocian) of Aargau, Switzerland. The sutures of the Ampthill Clay specimen are slightly less constricted than are those of the Swiss Bajocian form.

Genus TRISTIX Macfadyen 1941
Tristix oolithica (Terquem)

Text-fig. 2 (9)

1886 *Tritaxia oolithica* Terquem, p. 60, pl. 7, figs. 5*a*, *b*.
1937 *Trifarina oolithica* (Terquem); Bartenstein and Brand, p. 186, pl. 11B, fig. 26; pl. 15B, figs. 2*a–c*.

Material. One specimen from Knapwell.

Description. The test is triangular in cross-section, smooth, and consists of four chambers. Except on the first and last chambers, there is a prominent keel at the test margins. The aperture appears to be simple.

Dimensions. Length, 0·39 mm.

Remarks. Comparison of the Ampthill Clay specimen with the many specimens which I have found in rocks of comparable age on the Dorset coast indicates that this specimen is megalospheric. Terquem's original description of the species was from the Fuller's Earth of Warsaw.

Genus LINGULINA d'Orbigny 1826
Lingulina nodosaria Reuss

Text-fig. 2 (8)

1863 *Lingulina nodosaria* Reuss, p. 59, pl. 5, figs. 12*a*, *b*.
1953 *Lingulina* cf. *laevissima* (Terquem); Barnard, p. 186, figs. B, 8*a*, *b*.

Material. Three specimens from Knapwell; one from Mepal.

Description. The smooth rectilinear test consists of three to six chambers and its thickness is about two-thirds of the breadth. The margins are lobulate. The proloculum is subspherical, and subsequent chambers increase in size slowly and regularly. The sutures are depressed, arcuate. The apertural chamber is compressed-pyriform and the aperture is central, terminal, elliptical. No microspheric forms were found.

Dimensions. Lengths of the specimens, 0·38, 0·39, 0·45, and 0·5 mm.

Remarks. Reuss described this species from the Lower Cretaceous of north Germany. *Lingulina laevissima* (Terquem), described from the Lower Lias of Moselle, eastern France, differs in having sutures which are straight, transverse, except at the latest stage, and in being not indented at the margins until the final two chambers. Some of the forms which have been referred to Terquem's species are fairly similar to the Ampthill Clay specimens, but they commonly differ in being highly compressed. The form recorded by Barnard (1953) is compressed, but is otherwise very similar to my form and is considered to be conspecific with it.

Genus CITHARINA d'Orbigny 1839, emend. Marie 1938

It is not possible to draw a precise boundary between this genus and *Vaginulina*, but it seems to be useful to retain the name *Citharina* for compressed, triangular forms which have no coil. Glaessner (1945) considers that *Citharina* should be distinguished from *Vaginulina*, and Marie (1938) selected *Vaginulina striatula* Roemer 1842 as the genotype.

Citharina serratocostata (Gümbel)

Text-fig. 2 (11)

1862 *Marginulina serratocostata* Gümbel, p. 222, pl. 4, figs. 23*a*, *b*.
1862 *Marginulina flabellata* Gümbel, p. 223, pl. 4, figs. 24*a–c*.
1867 *Cristellaria lepida* Schwager, p. 657, pl. 34, fig. 9.
1890 *Vaginulina harpa* Roemer var. *furcata* Wisniowski, p. 209, pl. 9, fig. 6.
cf. 1917 *Vaginulina flabellata* (Gümbel); Paalzow, p. 237, pl. 45, figs. 5, 6, 7.
1921 *Vaginulina harpa* Roemer; Neaverson, p. 463, pl. 9, fig. 7.
1933 *Vaginulina lepida* (Schwager); Wickenden, p. 163, pl. 1, figs. 15, 16.
1937 *Vaginulina harpa* Roemer; Bartenstein and Brand, p. 163, pl. 14B, fig. 7; pl. 14C, fig. 10; pl. 15A, figs. 24*a*, *b*; pl. 15C, figs. 12*a–d*.
1950 *Vaginulina cataulaca* Loeblich and Tappan, p. 54, pl. 14, figs. 22, 23*a*, *b*.
1950 *Citharina entypomatus* Loeblich and Tappan, p. 57, pl. 15, figs. 1–12.
1950 *Vaginulina lancea* Lalicker, p. 16, pl. 3, fig. 3.
1950 *Vaginulina pola* Lalicker, p. 17, pl. 3, figs. 4*a*, *b*.
1950 *Vaginulina cetra* Lalicker, p. 17, pl. 3, fig. 5.
1953 *Citharina* cf. *serratocostata* (Gümbel); Barnard, p. 190, figs. A, 11*a–e*.
1954 *Vaginulina proxima* (Terquem); Bielecka and Pozaryski, pp. 44, 175, pl. 6, fig. 25.

Material. Seven specimens from Knapwell; thirty from Mepal.

Description. The test is compressed, triangular, broad to elongate, and composed of seven to sixteen chambers. The thickness of the test is one-third to a quarter of its width. The margins diverge rapidly at first but are frequently subparallel later. The apertural margin is entire, but the non-apertural margin is often lobulate especially later on. The proloculum is spherical or ellipsoidal, inflated or flush. A loose initial coil with triangular chambers is followed by a series of elongate, parallel sided, curving chambers with the greatest curvature near the apertural margin. The final chambers are straight, curved only at the apertural margin. The sutures may be depressed at the non-apertural margin, but otherwise they are flush. There is an ornament of coarse branching ribs. The apertural face is rectangular, smooth except at the margins where the terminations of the ribs produce frilling. The aperture is marginal, terminal, radiate or simple, often on a grooved neck from the last chamber.

Dimensions. Length, up to 2·0 mm.; usually about 1·0 mm.

Remarks. Many compressed, triangular, ribbed forms have been recorded from the Jurassic and Cretaceous under a variety of names, but the stylized mode of illustration adopted by many of the earlier authors has made it impossible to construct an entirely satisfactory synonymy for the Ampthill Clay specimens from the literature alone. In particular, many forms illustrated by Terquem (1868, pls. 1–7) from the Middle Jurassic of the Moselle Department are probably conspecific with the Ampthill specimens, but

any treatment of these without recourse to the original material would be inadequate or useless.

Citharina serratocostata was described by Gümbel from the lower Oxfordian of Streitberg, south Germany. The type specimen appears to be extremely narrow and the ribs are shown in the figure as if they do not branch, but there is little doubt that this belongs to the same species as the Ampthill forms. Some authors have ascribed to *Vaginulina harpa* Roemer forms which I regard as being conspecific with Gümbel's species, and it is possible that the Ampthill specimens should also be placed in this species. On the other hand, *Vaginulina harpa*, described by Roemer (1840–1) from the Lower Cretaceous (Hilsthon) of north Germany, was unsatisfactorily figured by the original author and it has been variously interpreted.

Forms which are the same as the Ampthill Clay species occur widely in the Middle and Upper Jurassic of Europe. They have also been recorded from the Jurassic of North America under different names. They occur in approximately the Bajocian of Saskatchewan and Alberta (Wickenden 1933); the Ellis group, approximately Bathonian, of Montana (Lalicker 1950); and the Redwater Shale, Upper Jurassic, of South Dakota (Loeblich and Tappan 1950*a*).

Genus FALSOPALMULA Bartenstein 1948

Falsopalmula anceps (Terquem)

Text-fig. 2 (10)

1870*b* *Flabellina anceps* Terquem, p. 223, pl. 23, figs. 25*a*, *b*.
1870*b* *Flabellina semi-involuta* Terquem (pars), p. 225, pl. 23, fig. 30; pl. 24, figs. 6–10.
1937 *Flabellina mölleri* Uhlig; Bartenstein and Brand, p. 169, pl. 15A, figs. 27*a–c*; pl. 15C, figs. 13*a*, *b*.
1948 *Falsopalmula semi-involuta* (Terquem); Bartenstein, p. 130, pl. 2, figs. 16–18.
1950 *Froudicularia spatha* Lalicker, p. 17, pl. 3, figs. 6*a–d*.
1950 *Citharinella exarata* Loeblich and Tappan, p. 58, pl. 16, figs. 4–8.

Material. Thirteen specimens from Knapwell; four from Mepal.

Description. The text is extremely variable in form, but it is usually lanceolate or lozenge-shaped, compressed, and consisting of eight to thirteen chambers. In most specimens, the thickness of the test is about one-quarter of the width, but the length varies widely. The margins of the test are entire at first, later becoming lobulate. The proloculum is spherical or ellipsoidal, usually flush, and in most specimens is followed by a loose coil of three to six chambers. The coil is succeeded by chevron-shaped chambers, the first of which partly embraces the coil at the peripheries. Except sometimes for the first one, the chevron-shaped chambers are bilaterally symmetrical. The sutures are flush. There is an ornament of coarse ribs, some of which branch. The aperture is central, terminal, radiate, on a neck from the last chamber. In the earlier growth stages, it is peripheral.

Dimensions. Length, 0·46–3·04 mm.

Remarks. Falsopalmula anceps was described by Terquem from the *parkinsoni* Zone (Bajocian) of Fontoy, Moselle, eastern France. The striate varieties of a group of specimens from the same beds which Terquem described as *Flabellina semi-involuta*

show a similar variation to that of the Ampthill specimens and should probably be placed in the same species.

Two North American forms appear to be conspecific with the Ampthill Clay specimens. *Citharinella exarata*, described from the Redwater Shale (Upper Jurassic) of South Dakota, seems to differ only in its slightly greater size; and *Frondicularia spatha*, from the Ellis group, Sawtooth member (approximately Bathonian) of Montana, differs slightly in having an oranment of ribs which are discontinuous, but is otherwise closely similar.

The generic placing of this species is made difficult by the transgression of the variation across the boundaries between widely accepted genera, but the median and most abundant forms fall within *Falsopalmula* Bartenstein.

Family EPISTOMARIIDAE
Genus VOORTHUYSENIA Hofker 1954
Voorthuysenia tenuicostata (Bartenstein and Brand)

Text-fig. 1 (7)

?1860*b* *Rotalia elegans* d'Orbigny; Jones and Parker, p. 452, pl. 20, fig. 46.
1898 *Pulvinulina elegans* (d'Orbigny); Chapman, p. 6, pl. 1, figs. 8*a–c*.
1898 *Pulvinulina caracolla* (Roemer); Chapman, p. 7, pl. 1, figs. 9*a–c*.
1932 *Epistomina caracolla* (Roemer); Paalzow, p. 142, pl. 11, figs. 12–14.
1935 *Epistomina elegans* (d'Orbigny); Macfadyen, p. 16, pl. 1, figs. 20*a*, *b*, *c*.
1951 *Epistomina tenuicostata* Bartenstein and Brand, p. 327, pl. 12A, figs. 325*a–c*.
1953 *Epistomina* cf. *elegans* (d'Orbigny); Barnard, p. 193, figs. A, 7*a–c*.
1954 *Voorthuysenia tenuicostata* (Bartenstein); Hofker, p. 186, figs. 19*a–g*.

Material. Seventy-five specimens from Knapwell; 108 from Mepal.

Description. The test is biconvex, trochoid, consisting of $1\frac{1}{2}$ to $2\frac{1}{2}$ whorls, with seven or eight chambers in the last whorl. The periphery is usually entire, but is sometimes weakly lobulate. The dorsal side is usually less strongly convex than the ventral. The height of the test is one-half to two-thirds of the greatest diameter. On the dorsal side, the whole spire is visible, and the slope of the spire may be either concave or convex. Frequently, there is a large dorsal boss which obscures the earlier chambers. The sutures are limbate, and they curve backwards from the inner margin to join the peripheral margin smoothly. On the ventral side, only the last whorl is visible; the sutures are limbate, radial, usually straight, and sometimes raised; the outlines of what are presumably secondary apertures are seen near the periphery on each chamber. The final whorl is sometimes excavated parallel to the periphery on each side of the test. The apertural face is triangular. The apertural chamber is broken in all specimens and the aperture was not seen.

The direction of the coiling may be dextral or sinistral, as tabulated below:

	Number of dextral specimens	*Number of sinistral specimens*	*Number of specimens in which the direction of coiling is obscure*
Knapwell	16	55	4
Mepal	34	67	7

Dimensions. Greatest diameter of the test, up to 0·59 mm.; usually it is 0·38–0·42 mm.

Remarks. This species was described by Bartenstein and Brand from the Valendisian of north-west Germany, but Hofker (1954) records it also from the Malm. An apparently similar form was recorded by Jones and Parker (1860*b*) from clay at Chellaston, Derbyshire, which they ascribed to the Upper Trias, but which Crick and Sherborn (1892), Issler (1908), and Macfadyen (1941) consider more likely to be Upper Liassic. Some of the Ampthill Clay specimens have thick, raised sutures which coalesce at the centre on both the dorsal and ventral sides; they are similar to *Voortluysenia pachyderma* Hofker from the Middle Jurassic, but in the Ampthill these forms grade into typical *V. tenuicostata.*

CONCLUSIONS

Of the seventeen species of foraminifera recorded from the Ampthill Clay, eight are Lagenids. This apparent predominance of the Lagenidae is less marked when a comparison is made on the basis of numbers of individual specimens which occur in the faunas. In the Knapwell fauna, 75 of the specimens found are Lagenids, 75 are *Voortluysenia tenuicostata* (Bartenstein and Brand), and 73 are other forms, principally *Ammobaculites coprolithiformis* (Schwager). In the Mepal fauna, the numbers are 148 Lagenids, 108 *V. tenuicostata*, and 51 others. The composition of the faunas of the two samples is shown in the table.

Distribution of the species of foraminifera

	Knapwell	Mepal
Cribrostomoides canui (Cushman)		×
Ammobaculites agglutinans (d'Orbigny)		×
Ammobaculites coprolithiformis (Schwager)	×	×
Ammobaculites cf. *reophaciformis* Cushman		×
Bigenerina cf. *nodosaria* d'Orbigny		×
Bullopora globulata Barnard	×	
Bullopora rostrata Quenstedt	×	
Trochammina squamata Jones and Parker		×
Lenticulina münsteri (Roemer)	×	×
Lenticulina suprajurassica	×	×
Planularia fraasi (Schwager)	×	
Nodosaria sowerbyi Schwager	×	
Tristix oolithica (Terquem)	×	
Lingulina nodosaria Reuss	×	×
Citharina serratocostata (Gümbel)	×	×
Falsopalmula anceps (Terquem)	×	×
Voortluysenia tenuicostata (Bartenstein and Brand)	×	×

The Knapwell fauna includes a greater variety of Lagenids, but only one species of arenaceous foraminifer, while the Mepal fauna has fewer species of Lagenids, but a more diverse set of arenaceous forms.

Considering the Knapwell and Mepal foraminiferal faunas together, the assemblage is more closely comparable to that of the Nothe Clay in the Dorset Corallian Beds than

to the fauna of any other formation. All the Ampthill Clay species except *Ammobaculites* cf. *reophaciformis* Cushman occur in the Nothe Clay, whereas the Glos Oolite Series of Dorset, more comparable in age to the Ampthill Clay, lacks several of the more characteristic Ampthill species including *Lenticulina suprajurassica* sp. nov. and *Voorthuysenia tenuicostata* (Bartenstein and Brand).

In general, the Ampthill Clay foraminiferal fauna is quite similar to the foraminiferal faunas of the Corallian Beds of Dorset, but the relative abundances of the species present in the Ampthill are distinctive. *Voorthuysenia tenuicostata* (Bartenstein and Brand) is the most important species in both the Knapwell and the Mepal samples, but in the Corallian of Dorset it is numerous only at restricted levels in the Nothe and Ringstead Waxy Clays. *Lenticulina suprajurassica* sp. nov. is common in the Ampthill Clay but scarcely represented in Dorset; while *Ammobaculites coprolithiformis* (Schwager) is extremely abundant in the upper Oxford Clay and lower Corallian of Dorset but is less abundant in the Ampthill Clay. On the whole, nevertheless, the foraminifera of the Ampthill Clay samples described in this paper are typical of the English Corallian Beds and of the Oxfordian stage.

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